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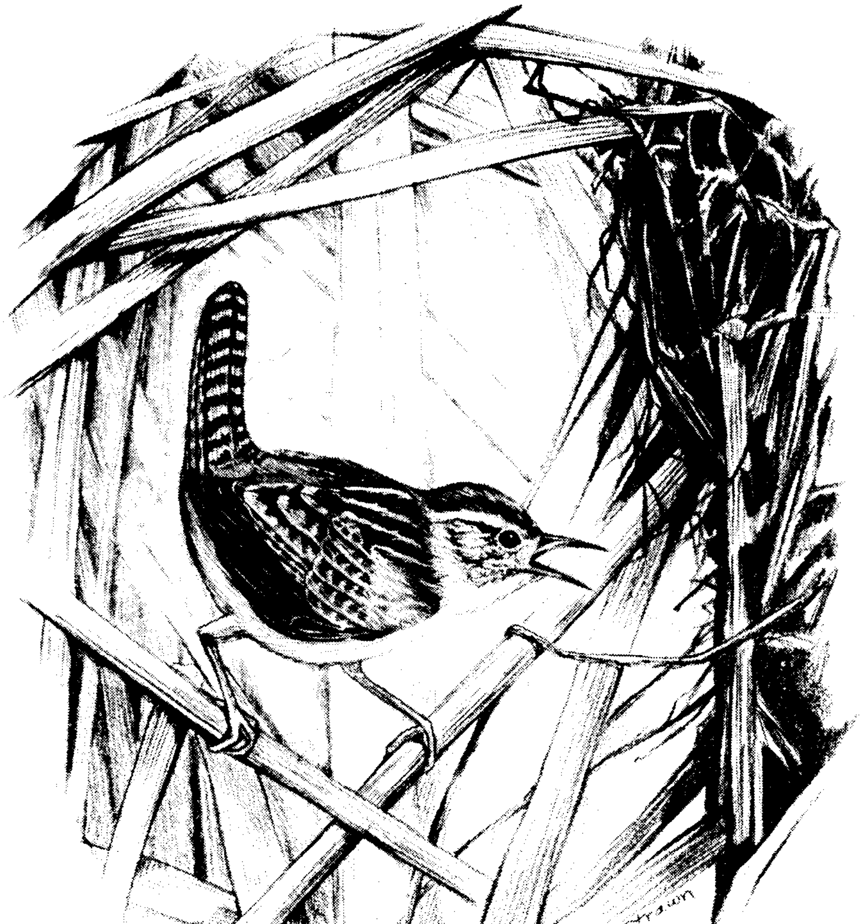
HABITAT SUITABILITY INDEX MODELS: MARSH WREN



Fish and Wildlife Service

U.S. Department of the Interior

Biological Report 82(10.139)
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HABITAT SUITABILITY INDEX MODELS: MARSH WREN

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PREFACE

This document is part of the Habitat Suitability Index (HSI) model series [Biological Report 82(10)], which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. This information provides the foundation for the HSI model and may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model section documents the habitat model and includes information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The HSI Model section includes information about the geographic range and seasonal application of the model, its current verification status, and a list of the model variables with recommended measurement techniques for each variable.

The model is a formalized synthesis of biological and habitat information published in the scientific literature and may include unpublished information reflecting the opinions of identified experts. Habitat information about wildlife species frequently is represented by scattered data sets collected during different seasons and years and from different sites throughout the range of a species. The model presents this broad data base in a formal, logical, and simplified manner. The assumptions necessary for organizing and synthesizing the species-habitat information into the model are discussed. The model should be regarded as a hypothesis of species-habitat relationships and not as a statement of proven cause and effect relationships. The model may have merit in planning wildlife habitat research studies about a species, as well as in providing an estimate of the relative suitability of habitat for that species. User feedback concerning model improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning are encouraged. Please send suggestions to:

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CONTENTS

FIGURES

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MARSH WREN (*Cistothorus palustris*)

HABITAT USE INFORMATION

General

The marsh wren (*Cistothorus palustris*) is a locally abundant breeding bird in freshwater and saltwater marshes throughout much of the United States and southern Canada (Bent 1948; Robbins et al. 1966). Marsh wrens winter in Mexico and on the gulf coast as far east as western Florida. In some maritime and southern climates, where marshes do not freeze over, marsh wrens are year-round residents (Bent 1948; Verner 1965; American Ornithologists' Union 1983).

Food

Insects and spiders are taken by marsh wrens from marsh vegetation, the marsh floor, and by flycatching. Insect orders commonly taken include Coleoptera, Diptera, Hemiptera, and Odonata. Carabidae and Dytiscidae dominate within Coleoptera, whereas Tipulidae composes most of the Diptera in marsh wren diets (Bent 1948; Kale 1964).

Food items brought to young depend on the age of the nestlings. Mosquitoes (Culicidae) and their larvae, midges (Chironomidae), larval tipulids, and other delicate stages of various insects are fed first. Later, as the nestlings mature, larger forms, such as ground beetles, diving beetles, long-horned beetles (Coleoptera), caterpillars (Lepidoptera), and sawflies (Hymenoptera), are brought to the young (Welter 1935).

Water

Marsh wrens living in salt marshes are apparently able to get sufficient dietary water from succulent insects and spiders (Kale 1967). We found no discussion in the literature of dietary water needs or water procurement techniques for marsh wrens breeding in freshwater environments. Marsh wrens bathe in saltwater and freshwater, but they apparently only drink freshwater (Kale 1967). Water also protects nests from predation and supports an important food source (arthropods) (Verner and Engelsen 1970).

Cover

Cover needs of the marsh wren are assumed to be the same as reproduction habitat needs and are discussed in the following section.

Reproduction

Marsh wrens typically nest in cattails (Typha spp.), bulrushes (Scirpus spp.), or sedges (Carex spp.). Other plants frequently present in nesting habitats include horsetails (Equisetum spp.), bluejoint reedgrass (Calamagrostis canadensis), reed canarygrass (Phalaris arundinacae), cordgrasses (Spartina spp.), annual wildrice (Zizania aquatica), spirea (Spiraea spp.), needle rush (Juncus roemerianus), and American mangrove (Rhizophora mangle) (Welter 1935; Bent 1948; Kale 1965; Verner 1965; Clapp and Abbott 1966).

This species typically nests in marshes where water depths range from several centimeters to 61 to 91 cm (Bent 1948). Marsh wrens usually do not nest in areas without some standing water (Verner and Engelsen 1970). In intertidal areas, however, nests are built in marshes where standing water may be present only during high tides or during periods of spring tides (H.W. Kale, Florida Audubon Society, Maitland, FL; letter dated August 11, 1985). Further, marshes that dry out by mid to late summer have been used successfully by nesting marsh wrens (Verner 1965), but permanent water through the breeding season is generally required to supply a dependable food source and security from predation (Verner and Engelsen 1970). Marsh wrens construct various layers of their nests with water-soaked vegetation that they obtain from the marsh (Welter 1935; Verner 1965).

Nests are normally anchored at least 38.1 cm above the ground; the average above-ground height for 21 nests measured in early June was 83.8 cm (Bent 1948). Occasionally, nests are placed in mangrove (Rhizophora spp.) trees 1.52 to 2.74 m above the ground (Bent 1948). Verner (1965) found mean nest heights varying from 76.2 to 92.7 cm above the marsh floor in cattails and bulrushes. Kale (1965) recorded nest heights, from early to late in the breeding season, that ranged from 0.5 m to 2.0 m above the marsh bed. Nests are typically placed 30 to 91 cm above standing water or high tide (Bent 1948). Nest height tends to increase with plant growth (Verner 1965); second nests generally yield higher mean heights than do first nests.

Bigamous and monogamous males nested in cattails much more frequently than if they had simply used cattails in proportion to their availability; male marsh wrens without mates did not exhibit this preference for cattails (Verner and Engelsen 1970). Verner (1964) reported a positive trend between the fraction of a male's territory covered by emergent vegetation (including floating portions of vegetation without standing water between roots and nests) and that male's pairing success. On the average, about 83.2% of the area of bachelor male territories at four marshes was covered by emergent vegetation (cattails and bulrushes); overall average percentages for these four marshes for monogamous and bigamous males were 85.1% and 87.8%. Verner (1964) suggested that this trend reflects the ability of female marsh wrens to recognize the amount of available feeding habitat in a male's territory. He thus implied that the proportion of a male's territory covered by emergent plants is a criterion used by female marsh wrens for mate selection. Marsh wrens tend to use denser areas of cattails because their nests require several stems for attachment (Burger 1985).

Interspersion and Movements

Marshes <0.40 ha are usually not used by breeding marsh wrens (Bent 1948), although Verner (J. Verner, Pacific Southwest Forest and Range Experiment Station, Forestry Sciences Lab, Fresno, CA; letter dated July 16, 1985) found nests in 0.04-ha patches of emergent, lakeside vegetation that were as much as 60 m from similar patches. Welter (1935) described a monogamous male territory that was 0.12 to 0.14 ha in a preferred cattail-sedge association; in a less preferred bluejoint-reedgrass-dominated wetland, a monogamous male held a 0.28 ha territory. Welter (1935) also noted that the territory of a bigamous male was almost twice that held by a monogamous male in the same vegetation type.

Verner (1964) found bachelor, monogamous, and bigamous marsh wrens holding territories that were, on the average, 0.08 ha, 0.13 ha, and 0.17 ha. Verner (1964) also noted one trigamous male with a territory that was 0.02 ha. Verner and Engelsen (1970) reported mean territory sizes for bachelor, monogamous, and bigamous marsh wrens of 0.05 ha, 0.06 ha, and 0.07 ha. There was no significant difference between these latter three means, nor was there a significant correlation between pairing success of males and their territory sizes, presumably because territory size was so variable. Indeed, among five Washington sites, mean territory size for all males ranged from 0.05 to 0.17 ha (Verner 1965). Kale (1965) reported mean territory size (for all males collectively) to range from 0.01 to 0.02 ha during four breeding seasons at nine study sites in Georgia.

Verner (1971) determined that the average dispersal distance between successive territory centers of 13 adult male marsh wrens during 2 consecutive years was approximately 386 m (range = 0 - 3353 m). Of these 13 males, five used the same territory in both years, and one set up a territory on a different lake during the second year. Ten yearling male marsh wrens established their first breeding territories at a mean distance of 1,951 m (range = 180 - 4090 m) from their natal lake. These mean dispersal distances for yearling versus adult males were significantly different ($0.01 > P > 0.001$) (Verner 1971).

Special Considerations

Marsh wren nestlings are occasionally consumed by common grackles (*Quiscalus quiscula*) (Welter 1935). Clapp and Abbott (1966) found a pilot black snake (*Elaphe obsoleta obsoleta*) that had preyed on marsh wren eggs. Rice rats (*Oryzomys palustris*), raccoons (*Procyon lotor*), and mink (*Mustella vison*) are important predators of marsh wren eggs and young in Georgia (Kale 1965). Yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) physically attack adult marsh wrens on the breeding grounds during territorial conflict (Burt 1970, cited in Picman 1980). Adult marsh wrens of both sexes destroy the eggs of other marsh wrens, presumably as a result of the evolution of intraspecific nest destruction, or perhaps because it decreases intraspecific competition for resources within a marsh (Picman 1977). Red-winged blackbirds (*Agelaius phoeniceus*) aggressively suppress the singing activities of marsh wrens and may, therefore, reduce marsh wren reproductive success. Nesting success in marsh wrens improves with increased distance between marsh wren breeding nests and the nearest red-winged blackbird nest (Picman 1982). Thus, the density of predators, breeding marsh wrens, and red-winged and yellow-headed blackbirds in a marsh may significantly influence its suitability as marsh wren breeding habitat.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model was developed for application throughout the breeding range of the marsh wren (Figure 1).

Season. This model was developed to evaluate breeding season habitat for the marsh wren.

Cover type. This model was developed to assess habitat suitability in permanently and semipermanently flooded estuarine, riverine, lacustrine, and palustrine wetlands that can be classed as emergent or scrub-shrub (Cowardin et al. 1979).

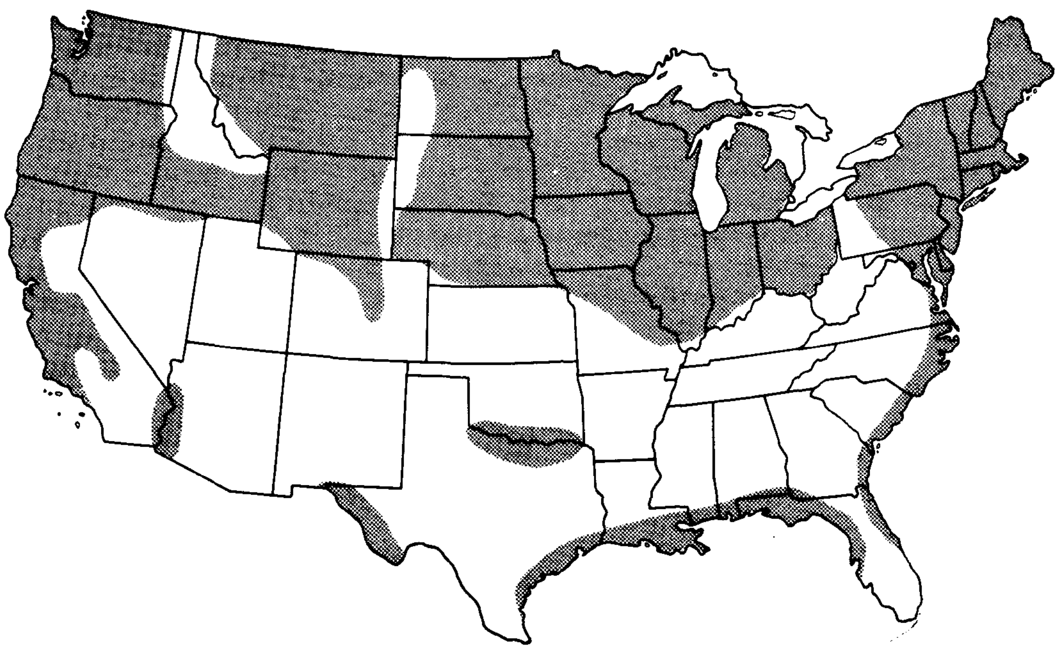

Figure 1. Approximate area of marsh wren model applicability. Range estimates were adapted from several sources (including Kale, unpubl. and Verner, unpubl.) that combine both breeding and year-round observations.

Minimum habitat area. Minimum habitat area is defined as the mininum amount of contiguous habitat that is necessary before an area will be used by a species. Marsh wrens do not usually nest in marshes that are <0.40 ha. Accordingly, it is assumed that if less than this amount of wetland (open water plus emergent vegetation) is present, the HSI is 0.

Verification level. Considerable interesting work has been conducted with marsh wrens in the areas of reproductive strategy (Verner 1964), and interspecific competition between it and other marsh-dwelling passerines (Picman 1983; Leonard and Picman 1986); however, information linking the species to habitat suitability is limited. For example, Verner and Engelsen (1970) were unable to exhibit statistically significant relationships between various measures of vegetation coverage within wren territories and pairing success of bachelor, monogamous, or bigamous males. Where marsh wrens occur with red-winged blackbirds and yellow-headed blackbirds, redwings tend to use the drier, shallower locations, yellowheads the deeper areas bordering open water, and marsh wrens the areas in between (Weller and Spatcher 1965; Burger 1985). Measures of habitat use under these conditions apparently reflect active spatial segregation among the three species, as wrens expand their territories into areas previously occupied by redwings or yellowheads after the blackbirds leave the marshes in late summer (Leonard and Picman 1986). How these relationships relate to habitat suitability is unknown.

The standard of comparison for this model focuses on male territories in wetlands as reported in the literature and interpreted by the authors. The potential of a permanently or semipermanently flooded wetland to support territorial males and, we assume, nesting marsh wrens is described; the model should be useful for baseline assessments and habitat management. The model is a set of hypotheses describing our interpretations of suitable marsh wren habitat conditions; however, it is not intended to serve as a predictor of numbers of wrens occupying a given wetland at any particular time. The model is intended to rate the suitability of potential nesting areas as would an expert thoroughly familiar with the reproductive requirements of marsh wrens; however, we have not evaluated the model's performance under actual field conditions.

Comments and suggestions from H.W. Kale, II, and J. Verner on an earlier draft of the marsh wren model were used to formulate the present model. Modifications suggested by these individuals have been incorporated into the model where possible. Use of the reviewers' names, however, does not necessarily imply that they concur with each section of the model, or the model in its entirety.

Model Description

Overview. Cover and reproduction requirements of the marsh wren are combined into a single habitat component because these needs are assumed to be supplied by the same habitat features. It is assumed that if the cover and reproduction needs are satisfied, adequate amounts of food and water will also be available.

In the sections that follow, we document the logic and assumptions used to relate marsh wren habitat information to the variables and equations used in this model. Specifically, we identify variables used in the model, define and justify suitability levels for each variable, and describe the assumed relationships between variables.

Cover/reproduction component. It is assumed that the cover and nesting requirements for marsh wrens can be supplied by herbaceous wetlands that support hydrophytes, such as cattails, bulrushes, cordgrasses, sedges, and other species, and that contain standing water. Marsh wrens tend to avoid areas of abundant woody vegetation, thus high tree or shrub densities are assumed to lower the value of a wetland for nesting marsh wrens. Verner (unpubl.) found marsh wrens nesting in a stand of *Spiraea aquatica* in Washington; isolated trees and shrubs did not preclude habitat use. Instead, woody vegetation was used for singing and feeding sites.

Early accounts describing the nest sites of marsh wrens identify a wide variety of emergent species used as nest support (Bent 1948). A common characteristic of nest-support vegetation is several erect and closely spaced stalks or limbs that together provide the strength and height to support a bulky nest (approximately 12.5 x 17.5 cm) at least several centimeters above the water surface. Cattails and cordgrasses appear to provide a growth form commonly acceptable to nest-building marsh wrens; bulrushes are also important, especially during drier years (Verner and Engelsen 1970). Aquatic emergents exhibiting a growth form similar to cattails, cordgrass, or bulrush are assumed to provide ideal conditions for nest building and the general cover requirements for marsh wrens (SIV1, Figure 2). Species such as bluejoint reedgrass, reed canarygrass, and sedges are also used by marsh wrens, but are assumed to provide lower suitability because of their different structure, or shorter stature and assumed lower stem strength, than that exhibited by cattails and similar species. Emergent species with growth forms differing significantly from those described above [e.g., buttonbush (*Cephalanthus occidentalis*) and mangrove (*Rhizophora* spp.)], but that are occasionally used to support nests, are assumed to have very low suitability. The assignment of a suitability index to emergent vegetation not specifically identified above will require some judgement by the user.

Although Verner and Engelsen (1970) were unable to exhibit statistical relationships between cover and pairing status, we feel that some consideration of relative availability of emergent vegetation for breeding marsh wrens is required to characterize cover/reproduction suitability. Most studies indicate or imply that marsh wrens use areas supporting relatively dense emergent vegetation for territories and nesting. The lowest mean percent coverage of emergent vegetation recorded for territorial males in Washington was 50% for bachelors using "blue" marsh (Verner 1964:257). Coverage of emergent vegetation in other territories in other marshes ranged from 57% to 100%. A diagram of marsh wren territories provided by Leonard and Picman (1986:136) also indicates the use of areas with extensive vegetation coverage, at least while yellow-headed blackbirds were present.

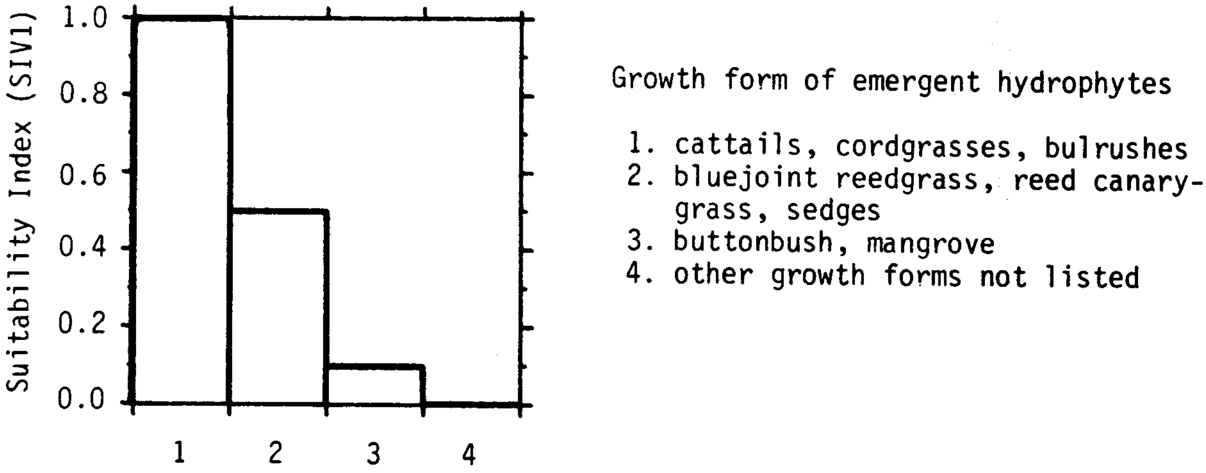

Figure 2. The assumed relationship between the growth form of emergent hydrophytes and the suitability of a wetland as cover/reproduction habitat for marsh wrens.

We present the above information as increasing suitability with increasing percent canopy cover of emergent herbaceous vegetation (SIV2, Figure 3). Fifty percent canopy cover is assigned a value of 0.1, and optimum conditions are reached at 80%. These values are somewhat arbitrary, as use may equal availability after some coverage threshold is reached, especially in wetlands also used by red-winged or yellow-headed blackbirds. The ultimate determination of nesting suitability may depend on female assessments of food resources within the territory, which are based on as yet unknown characteristics (Verner and Engelsen 1970).

Wetlands without standing water usually are not used for nesting by marsh wrens, although intertidal coastal marshes and other marshes that periodically lack standing water are acceptable (Verner 1965; Kale, unpubl.). Information relating water depths to cover/reproduction suitability was not located; however, we have assumed a linear increase in suitability as mean depth increases (SIV3, Figure 4). Optimum conditions are assumed to occur at a minimum mean depth of 15 cm. The upper depth limit for standing water is unknown, and the graph for SIV3 indicates no limit. In reality, as water increases in depth, some threshold will be reached at which growth of emergent herbaceous vegetation will be affected, and the suitability of the wetland as represented by SIV1 and SIV2 will decrease.

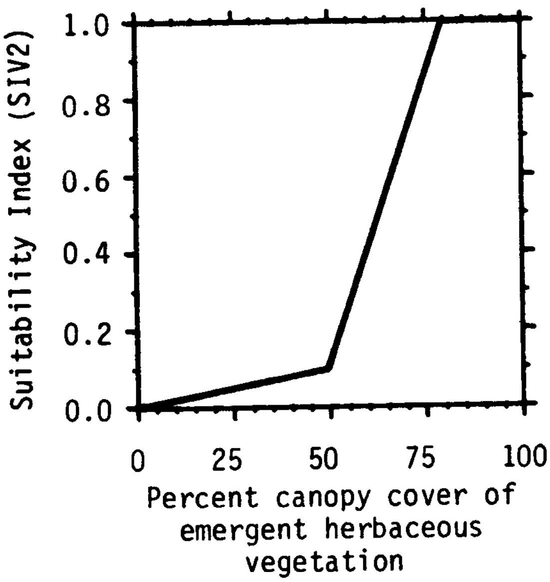

Figure 3. The assumed relationship between percent canopy cover of emergent herbaceous vegetation and cover/reproduction suitability of a wetland for marsh wrens.

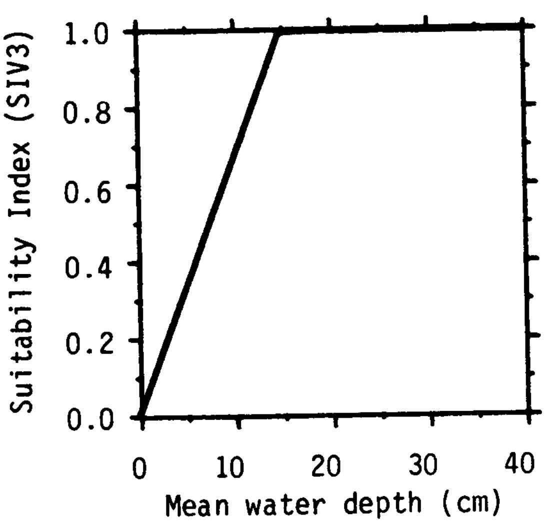

Figure 4. The assumed relationship between mean water depth and cover/reproduction suitability of a wetland for marsh wrens.

The effect of woody vegetation on marsh wren habitat suitability is unclear. Bent (1948) cites several early studies from the eastern United States that document nesting in woody vegetation; however, the relative importance of this activity in the overall nesting effort of the populations under study is unknown. More recent studies emphasize emergent herbaceous vegetation as nesting substrate. Therefore, for the purposes of this model, woody vegetation is assumed to lower the suitability of wetlands for nesting marsh wrens. Forested wetlands with >30% coverage of trees >6 m in height (U.S. Fish and Wildlife Service 1981) are considered unsuitable. Shrub-dominated wetlands (>30% coverage of woody plants <6 m tall) may have some value for nesting marsh wrens, but the value of both herbaceous and deciduous-shrub wetlands are assumed to decrease with increasing canopy closure of woody vegetation (SIV4, Figure 5). Wetlands supporting trees with <30% canopy coverage should be evaluated as either emergent or scrub-shrub wetlands.

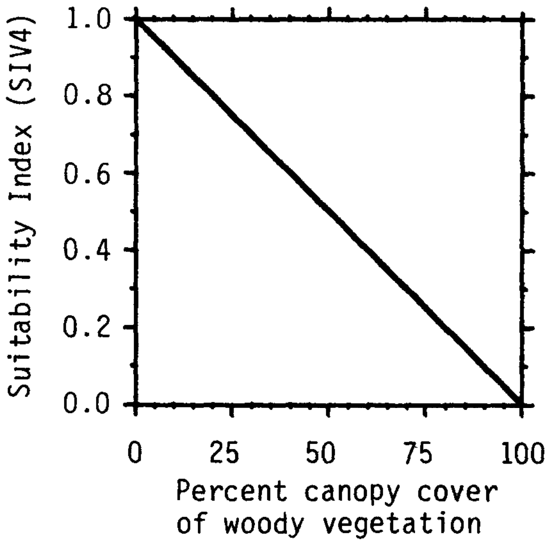

Figure 5. The assumed relationship between percent canopy cover of woody vegetation and cover/reproduction suitability of a wetland for marsh wrens.

HSI determination. We have assumed that habitat suitability, in terms of cover/reproduction for the marsh wren, is a reflection of the characteristics of individual permanently or semipermanently flooded estuarine, riverine, lacustrine, or palustrine wetlands classed as emergent or scrub-shrub (Cowardin et al. 1979). Criteria characterizing the growth form of emergent vegetation (SIV1), the percent canopy cover of emergent herbaceous vegetation (SIV2), mean water depth (SIV3), and the percent canopy cover of woody vegetation (SIV4) can be used to assess suitability. Suitability among the first three variables is compensatory, i.e., a low value for one index can be compensated for by a high value in one of the other indices. A zero value for any of the three variables, however, indicates a wetland that is unsuitable in terms of cover/reproduction requirements for marsh wrens. The relationship between woody vegetation and habitat suitability is unclear, but we have assumed a negative affect on overall cover/reproduction suitability as the percent canopy cover of woody vegetation increases. Thus, SIV4 is used to lower the value of a wetland supporting woody vegetation. These relationships are described by equation 1.

$$HSI = (SIV1 \times SIV2 \times SIV3)^{1/3} \times SIV4 \qquad (1)$$

Application of the Model

Summary of model variables. Four habitat variables are used in this model to characterize the suitability of a wetland for supplying cover and reproductive needs of marsh wrens. Relationships among these variables, the cover and reproduction component, and the HSI value are summarized in Figure 6. During application of this model, variables should be defined and measured as discussed in Figure 7.

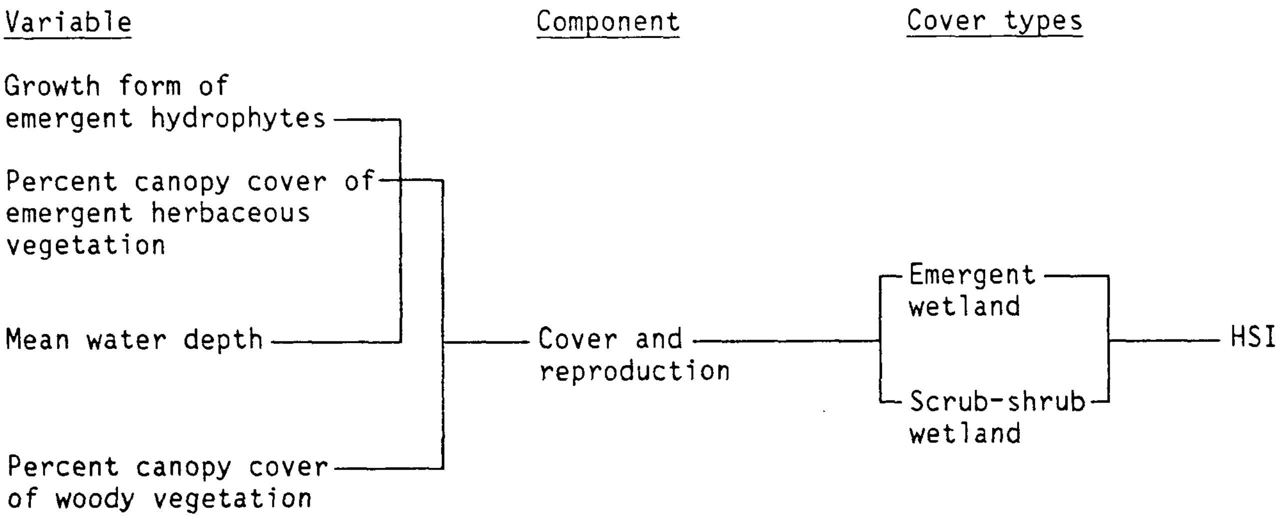

Figure 6. Relationship among habitat variables, component, cover types, and HSI for the marsh wren.

Variable (definition)	Cover type	Recommended technique
Growth form of emergent hydrophytes.	Emergent and scrub-shrub wetlands	Aerial photos, on-site inspection
Percent canopy cover of emergent herbaceous vegetation (the percent of the water surface shaded by a vertical projection of the canopies of emergent herbaceous vegetation, both persistent and nonpersistent).	Emergent and scrub-shrub wetlands	Line intercept
Mean water depth (cm).	Emergent and scrub-shrub wetlands	Graduated rod
Percent canopy cover of woody vegetation (the percent of the ground surface that is shaded by a vertical projection of the canopies of all woody vegetation).	Emergent and scrub-shrub wetlands	Line intercept

Figure 7. Definition of variables, applicable cover types, and recommended measurement techniques (Hays et al. 1981) for the marsh wren model.

Model assumptions. This model was developed to assess the habitat suitability of wetlands for supplying the cover and reproductive needs of marsh wrens. The model is not intended to produce outputs that reflect actual population densities at any particular time, but rather it attempts to estimate the potential of a site to supply the habitat requirements as defined above, regardless of nonhabitat variables influencing populations. Model variables and relationships are based on information obtained from studies disjunct in time and space. As such, the model is a collection of hypotheses and should not be interpreted as statements of proven cause and effect. Users should refine the model as necessary to better represent localized conditions.

Three basic assumptions characterize the model. First, we assume that the growth form of herbaceous hydrophytes and percent canopy cover of emergent herbaceous vegetation in a wetland are dominant factors determining habitat suitability for marsh wrens. Second, we assume that any depth of water ≥15 cm, if present during the breeding season, indicates optimum conditions. Wetlands lacking such conditions would be unsuitable by definition of this variable. No information was located that could be used to relate various degrees of water permanence throughout the breeding season with relative suitability. Third, we assume that changes in suitability of marsh wren habitat follow a direct linear response to changes in woody vegetation canopy cover, although the influences of woody vegetation are difficult to interpret from the literature.

SOURCES OF OTHER MODELS

No other habitat models for the marsh wren were found.

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

A review and synthesis of existing information were used to develop a Habitat Suitabiltiy Index (HSI) model for the marsh wren (Cistothorus palustris). The model consolidates habitat use information into a framework appropriate for field application, and is scaled to produce an index between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). HSI models are designed to be used with Habitat Evaluation Procedures previously developed by U.S. Fish and Wildlife Service.

17. Document Analysis a. Descriptors

Birds
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Habitability
Mathematical models

b. Identifiers/Open-Ended Terms

Marsh wren
Cistothorus palustris
Habitat suitability

c. COSATI Field/Group

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	20. Security Class (This Page)	22. Price
	Unclassified	

(See ANSI–Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-
(Formerly NTIS–35)
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